

Effects of Nutritional Factors on Chemical and Soil Microbiostasis

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EFFECTS OF NUTRITIONAL FACTORS ON CHEMICAL AND SOIL MICROBIOSTASIS

Wen-hsiung Ko

ABSTRACT

The majority of reports concerning the effects of nutritional factors on inhibition of microorganisms dealt with the inactivation of antimicrobial agents, and only a few cases of enhancement of antimicrobial activity of chemicals by nutrients were documented. The effects of nutritional factors on fungistasis was most extensively studied among the three types of soil microbiostasis, followed by bacteriostasis and antinostasis. Agar, sulfur-containing amino acids, vitamins, and mineral salts which are very effective in inactivating considerable numbers of antimicrobial agents are, in general, ineffective in annulment of soil microbiostasis. These differences suggest that soil microbiostasis is not due to chemical inhibition.

Key Words: carbohydrates, fungistasis, lipids, nucleic acids, proteins.

I. MICROBIOSTASIS INDUCED BY CHEMICALS (TABLE 1)

The effects of nutritional factors on inhibition of microorganisms by chemicals was reported as early as 1913 (145). However, most information on this subject has been obtained since 1940. The great majority of reports dealt with the inactivation of antimicrobial agents, and only a few cases of enhancement of antimicrobial activity of chemicals by nutrients were documented. Comparisons of antimicrobial activity of chemicals in the presence or absence of a nutritional factor have been made by measuring (1) spore germination or mycelial growth of fungi (33,309); (2) minimum inhibitory concentration (229,256); (3) effective dose for 50 percent response (ED₅₀) (53,137); (4) cell growth of bacteria (21,81,208,296,298); (5) viability of fungal spores (263) and (6) oxygen consumption (14,306). Mechanisms by which nutritional factors affect microbiostasis induced by chemicals have been reviewed (77,95,181,286).

In Table 1, the nutritional factors which are capable of inactivating antimicrobial agents are divided into eight major groups:

1. *Carbohydrates and related compounds.* This group includes monosaccharides, oligosaccharides, polysaccharides, sugar acids, and sugar alcohols.
2. *Proteins and related compounds.* This group includes amino acids, derivatives of amino acids, peptides, proteins, and enzymes.
3. *Nucleic acids and related compounds.* This group includes purines, pyrimidines, nucleosides, nucleotides, and nucleic acids.
4. *Lipids and related compounds.* This group includes fatty acids, phospholipids, and steroids.
5. *Vitamins and related compounds.*
6. *Mineral salts.*
7. *Miscellaneous compounds.*
8. *Mixtures and complex substances.* In this group, the most commonly used substances are casamino acids, yeast extracts, and serum.

Some of the nutritional factors were listed in groups because of their similarities in chemical structure and function. When more than three microorganisms were used in the same tests, only the numbers of microorganisms were indicated. Therefore, interested readers are urged to consult the original references for detailed information.

II. MICROBIOSTASIS INDUCED BY NATURAL SOIL

Microorganisms including fungi, actinomycetes, and bacteria remain quiescent or decrease in number when they are introduced into natural soil (127,133). Such microbiostasis is a general phenomenon of natural soil (133).

Tables 2-4 list the nutritional factors that are capable of decreasing or increasing soil microbiostasis, and also the microorganisms tested. Those nutrients shown to be ineffective are also included. The grouping of nutritional factors in these tables is the same as that in Table 1.

A. Soil Fungistasis (Table 2)

Although inability of fungi to multiply when added to soil was reported by Katznelson in 1940 (127), intensive research on soil fungistasis started only after the report by Dobbs and Hinson in 1953 (46). In microbiostasis of soil, fungistasis has been investigated most extensively, far more than have actinostasis and bacteriostasis. This probably is because most soil-borne plant diseases are caused by fungi, which are the largest in size among the three groups of microorganisms and, therefore, are the easiest to study.

Techniques for assaying the influence of soil on germination of fungal propagules have been reviewed recently (160). To study the effect of nutritional factors on soil fungistasis, nutrients are usually

added to soil directly, or to agar discs placed on soil or above soil (soil emanation), or, less frequently, added to soil extracts. Since inhibition of spore germination of most fungi in soil is complete, enhancement of fungistasis by nutrients is difficult to detect unless insensitive fungi are used, or soils are made less fungistatic to provide partial germination of the test fungi. This, apparently, is one of the reasons why only very few examples of fungistasis enhancement by nutrients have been reported (Table 2). Mechanisms concerning annulment of soil fungistasis by nutrients have been reviewed recently by Lockwood (160).

B. Soil Actinostasis (Table 3)

Very few research works concerning inhibition of actinomycetes in soil have been reported even though it was noted as early as 1940 by Katznelson (127) that actinomycetes introduced into soil did not increase in number. For studying the effect of nutritional factors on actinostasis, nutrients were added to soil directly or to agar discs placed on soil. Percentage of spore germination (159) or number of propagules (127) in soil, or colony size (30) in agar discs was measured after incubation.

C. Soil Bacteriostasis (Table 4)

In 1909, Russell and Hutchinson (220) reported that the number of bacteria per gram of soil remained fairly constant in natural soil, whereas, in partially sterilized soil, bacteria multiplied rapidly. This phenomenon was subsequently shown by Hutchinson and Theysen (108) in 1918 to be due to lack of nutrients rather than the presence of bacteriotoxins in soil. Since then, little research has been done on soil bacteriostasis until the report by Brown (30) in 1973 when the interest on this

subject was revived. The effects of nutritional factors on soil bacteriostasis have been studied by adding nutrients to soil, to agar discs placed on soil, or to soil extract and measuring the number of propagules in soil (220) or soil extract (108), or the colony size in agar discs (30).

III. COMPARISON OF MICROBIOSTASIS INDUCED BY CHEMICALS AND NATURAL SOIL

Significant discoveries of the effects of nutritional factors on microbiostasis induced by chemicals include the following: 1) Reversal of bacteriostasis action of sulfanilamide against certain bacteria by p-aminobenzoic acid (295); 2) protection of fungi against polyene antibiotics by sterols (78); 3) detoxification of antimicrobial agents by the sulfur-containing amino acid, cysteine (53); 4) reversal of activity of antimicrobial compounds by metals (307); 5) degradation of antibiotics by enzymes (203). Considerable numbers of antimicrobial agents were inactivated by agar (Table 1). This deserves special attention because agar media have frequently been used in the assay of inhibitory substances. A solidifying agent with minimal effect on activity of antimicrobial substances was found recently by Ho and Ko (Phytopathology 70:764-766, 1980).

The following generalizations regarding reversal of soil microbiostasis by nutrients may be recognized:

1. Different species or different clones of the same species may have different nutrient requirements for annulment of soil microbiostasis.
2. Soil microbiostasis of a given microorganism may be reversed by different nutritional factors.
3. Mixtures and complex substances containing carbon sources in general

are very effective in reversing soil microbiostasis, whereas inorganic salts are mostly ineffective.

4. Effectiveness of a nutritional factor on soil microbiostasis of a microorganism may be affected by the assay method used.

Although chemical and soil microbiostasis share some common nutritional factors in the reversal of the inhibitory activity, the following important differences may be recognized:

1. Agar is very effective in inactivating antimicrobial agents, but is usually less effective or ineffective in reversing soil microbiostasis. In fact, agar discs have been used frequently in assaying soil microbiostasis.
2. Detoxification of antimicrobial agents by sulfur-containing amino acids, especially cysteine, is a well-known phenomenon in chemical microbiostasis. However, these compounds are generally ineffective in annulment of soil microbiostasis.
3. Vitamins and related compounds are capable of reversing a number of antimicrobial agents, but are mostly ineffective in reversing soil microbiostasis.
4. Inactivation of antimicrobial agents by mineral salts is a common phenomenon in chemical microbiostasis. However, these compounds are, in general, ineffective in annulment of soil microbiostasis. As a matter of fact, they are the common constituents of soil.

These differences suggest that soil microbiostasis is not due to chemical inhibition. Reversal of soil microbiostasis can be explained as the result of fulfillment of nutritional requirements for germination and growth rather than inactivation of inhibitory substances in soil (133,138).

TABLE 1. Effects of Nutritional Factors on Microbiostasis Induced by Chemicals

Nutritional factor	Chemical affected	Test microorganism	Reference
I. Microbiostasis Decreased			
<u>Carbohydrates and Related Compounds</u>			
Glucose	Pyridinethione	<u>Collectotrichum phomoides</u>	217
	Ba(NO ₃) ₂	<u>Monilia sitophila</u>	145
	NH ₄ Cl,	<u>M. sitophila</u>	146
	NaCl,		
	CaCl ₂ ,		
	CuCl ₂ ,		
	ZnCl ₂ ,		
	CoCl ₂ ,		
	CdCl ₂ ,		
	HgCl ₂ ,		
	Nystatin	<u>Saccharomyces cerevisiae</u>	256
	Nystatin	<u>Candida albicans</u>	256
	Ethylene thiuram disulphide,	<u>Alternaria brassicicola</u>	50
	Nabam,		
	Dinocap,		
	Triphenyltin acetate, 6-Azaauracil		
Fructose	Ethylene thiuram disulphide	<u>A. brassicicola</u>	50
Xylose	Pyridinethione	<u>Collectotrichum phomoides</u>	217
Mannose	Ethylene thiuram disulphide	<u>Alternaria brassicicola</u>	50
Sucrose	Streptomycin,	<u>Pythium ultimum</u>	274
	Griseofulvin,		
	Aureomycin		
	Aureomycin	<u>P. irregulare</u>	274
	Aureomycin	<u>Staphylococcus aureus</u>	112
	CaCl ₂ ,	<u>Monilia sitophila</u>	146
	CuCl ₂ ,		
	ZnCl ₂ ,		
	CoCl ₂ ,		
	HgCl ₂ ,		
	Nystatin	<u>Saccharomyces cerevisiae</u>	256
	Nystatin	<u>Candida albicans</u>	256

	Czapek's mineral salts	<u>Alternaria solani</u>	137
	Czapek's mineral salts	<u>Calonectria crotalariae</u>	137
	Czapek's mineral salts	<u>Helminthosporium maydis</u>	137
Maltose	Nystatin	<u>Saccharomyces cerevisiae</u>	256
	Nystatin	<u>Candida albicans</u>	256
Lactose	Pyridinethione	<u>Colletotrichum phomoides</u>	217
	Nystatin	<u>Saccharomyces cerevisiae</u>	256
	Nystatin	<u>Candida albicans</u>	256
	KCl,	<u>Monilia sitophila</u>	146
	NaCl		
	ZnCl ₂ ,		
	CdCl ₂		
Trehalose, Gentiobiose	Ethylene thiuram disulphide	<u>Alternaria brassicicola</u>	50
Starch	Aureomycin	<u>Staphylococcus aureus</u>	112
	NaCl,	<u>Monilia sitophila</u>	146
	CaCl ₂ ,		
	FeCl ₃ ,		
	CoCl ₂ ,		
	CdCl ₂ ,		
Dextrin	Aureomycin	<u>Staphylococcus aureus</u>	112
Pectin, Chondroitin, Gum, Pneumococcal poly- saccharides	Aureomycin	<u>Colpoda cucullus</u>	158
Heparin, Alginic acid	Aureomycin, Dihydrostreptomycin, Chloromycetin Terramycin	<u>C. cucullus</u>	158
Agar	Polymyxin,	<u>Staphylococcus aureus</u>	93
	Neomycin,		
	Kanamycin,		
	Streptomycin		
	Streptomycin, Aureomycin,	<u>S. aureus</u>	112

	Chloromycetin,		
	Penicillin		
	Nystatin	<u>Candida albicans</u>	256
	Nystatin	<u>Saccharomyces cerevisiae</u>	256
	8 Phenolic compounds	<u>Staphylococcus aureus</u>	222
	Phenol	11 Bacteria	81
	Laurylamine	9 Bacteria	81
	11 Fatty amines	<u>Staphylococcus aureus</u>	92
	5-Diazouracil,	<u>Escherichia coli</u>	83
	1-Methyl-3-nitro-1-nitrosoguanidine		
	Cetavlon	<u>Staphylococcus aureus</u>	204
	Ceepryn	<u>S. aureus</u>	204, 210
	Zephiran,	<u>S. aureus</u>	210
	Phemerol,		
	Cetamium		
	Methylaminoacridine	<u>S. aureus</u>	16, 17
	Proflavine	<u>S. aureus</u>	17
	Octyl alcohol,	<u>Mycobacterium tuberculosis</u>	7
	Diamyl sodium sulfo-succinate,		
	Dibutyl sodium sulfo-succinate,		
	Sodium stearate,		
	Potassium stearate		
	Sodium ricinoleate,	<u>M. tuberculosis</u>	7
	Glycerol monooleate,	<u>M. phlei</u>	
	Sodium oleyl sulphate,		
	Sodium oleate,		
	Lecithin		
	CuSO ₄	<u>Alternaria solani</u>	137
	CuSO ₄	<u>Calonectria crotalariae</u>	137
	CuSO ₄	<u>Helminthosporium maydis</u>	137
	Dithane M-45,	<u>Alternaria solani</u>	137
	Mertect,		
	ZnCl ₂ ,		
	ZnSO ₄		
	AlCl ₃ ,		
	FeSO ₄ ,		
	Na ₂ HAsO ₄ ,		
	NaCl,		
	KCl,		
Glycerol	Laurylamine	15 Bacteria	81
	Phenol	16 Bacteria	81
Thioglycerol	Captan	<u>Saccharomyces pastorianus</u>	166
Thioglycolate	Clavacin,	5 Bacteria	71
	Penicillic acid		
	HgCl ₂ ,	<u>Salmonella paratyphi</u>	14
	Allyl-2-propene-1-thiosulfinate		

	Tetramethylene diisocyanate, Nabam Arsphenamide, Neoarsphenamide, Silver arsphenamide, Arsenoxide, Bismuth, HgCl ₂ ,	<u>Penicillium italicum</u> , <u>Aspergillus niger</u>	123
		<u>Spirocheta pallida</u>	53
Quinaldic acid	Oxine	<u>Stemphylium sarcinaeforme</u>	308
	Oxine	<u>S. sarcinaeforme</u> , <u>Monilinia, fructicola</u>	309
Digitonin	Nystatin, Amphotericin B	<u>Candida albicans</u>	72
N-acetylglucosamine	Bacillin	4 Bacteria	279
Citrate	Copper	<u>Mycobacterium phlei</u>	208
	Bordeaux mixture	4 Fungi	174
	Oxamycin, Morin, Patulin	<u>Bacillus subtilis</u>	288
	Usnic acid	<u>B. subtilis</u>	29
	Juglone	<u>B. subtilis</u>	258
Acetate	Propionate	<u>Streptococcus faecalis</u>	98
Tartrate	Oxamycin Morin, Patulin Juglone Copper	<u>B. subtilis</u> <u>B. subtilis</u> <u>Alternaria alternata</u>	288 258 22
Oxalate	Actidione	<u>Saccharomyces cerevisiae</u>	258
	Juglone	<u>Bacillus subtilis</u>	258
	Oxamycin, Morin, Patulin	<u>B. subtilis</u>	288
	Usnic acid	<u>B. subtilis</u>	29
Malic acid	Copper	<u>Alternaria alternata</u>	22
Pyruvic acid, 2-Ketoglutaric acid, 2-Ketobutyric acid, Dimethyl pyruvic acid	Sodium dimethyl- dithiocarbamate	<u>Penicillium italicum</u>	124
<u>Proteins and Related Compounds</u>			
Asparagine	Ascochitine Copper	<u>Cochliobolus miyabeanus</u> <u>Alternaria alternata</u>	198 22

	Streptomycin, Griseofulvin, Actidione, Aureomycin Aureomycin	<u>Pythium ultimum</u> <u>P. irregulare</u>	274 274
Aspartic acid	Furacin	<u>Escherichia coli</u>	82
Glutamine	Ascochitine	<u>Cochliobolus miyabeanus</u>	198
Glutamic acid	Phenyl pantothenone Copper Aureomycin, Terramycin, Dihydrostreptomycin Ethylene thiuram disulphide	<u>Saccharomyces cerevisiae</u> <u>Mycobacterium phlei</u> <u>Escherichia coli</u> <u>Alternaria brassicicola</u>	297 208 66 50
Alanine	Cycloserine Cycloserine Cycloserine Cycloserine Cycloserine Cycloserine Cycloserine Ascochitine	<u>Bacillus subtilis</u> <u>Pediococcus cerevisiae</u> Causal organisms of psitacosis, pneumonitis, meningopneumonitis, felinepneumonitis <u>Staphylococcus aureus</u> <u>Streptococcus fecalis</u> <u>Mycobacterium acapulonsis</u> <u>Pseudomonas aeruginosa</u> , <u>Escherichia coli</u> <u>Cochliobolus miyabeanus</u>	67, 11 310 189 26 240 188 111 198
Arginine	Canavanine Furacin Dihydrostreptomycin, Terramycin Ascochitine L-Canavine	<u>Lactobacillus casei</u> , <u>L. arabinosus</u> , <u>L. delbrueckii</u> <u>Escherichia coli</u> <u>E. coli</u> <u>Cochliobolus miyabeanus</u> <u>Neurospora sp.</u>	 277 82 66 198 107
Glycine	Aureomycin Terramycin Sulfonamide Copper	11 Bacteria <u>Escherichia coli</u> <u>E. coli</u> , <u>Alternaria alternata</u>	66 66 139 22
Phenylalanine	Furacin Chloromycetin, Dihydrostreptomycin Halogenate phenyla- lanine	<u>Escherichia coli</u> <u>E. coli</u> <u>Neurospora sp.</u>	82 66 186
Proline	Hydroxyproline	<u>Trichophyton sp.</u>	218

Serine	Sulfonamide	<u>Escherichia coli</u>	139
Leucine	Penicillin G, Terramycin	<u>E. coli</u>	66
Isoleucine	Furacin	<u>E. coli</u>	82
Lysine	Furacin	<u>E. coli</u>	82
	Arginine	<u>Neurospora</u> sp.	49
Valine	Penicillin G.	<u>Escherichia coli</u>	66
Tyrosine	Penicillin G, Chloromycetin	<u>Escherichia coli</u>	66
Tryptophane	Penicillin G	<u>E. coli</u>	66
	Oxine	<u>Aspergillus niger</u>	309
Threonine	Borrelidin	<u>Bacillus subtilis</u>	205
Methionine	2-Chloro-4-benzoic acid	<u>Escherichia coli</u>	280
	Terramycin	<u>E. coli</u>	66
	Selenate	<u>Chlorella vulgaris</u>	241
	Selenium	<u>Aspergillus niger</u>	289
	Sulfonamide	<u>Escherichia coli</u>	139, 259
	Sulfanilamide, Sulfapyridine, Sulfadiazine, Sulfathiazole	<u>E. coli</u>	94
Cystine	Selenium	<u>Aspergillus niger</u>	289
Cysteine	Clavacin, Penicillic acid	5 Bacteria	71
	Cobalt	<u>Proteus vulgaris</u>	228
	HgCl ₂ ,	<u>Salmonella paratyphi</u>	14
	Allyl-2-propene-1- thiosulfinate		
	Phenylmercuric nitrate	<u>Escherichia coli</u>	262
		<u>Staphylococcus aureus</u> ,	
		<u>Eberthella typhosa</u>	
	Tetramethylene diiso- cyanate,	<u>Penicillium italicum</u> ,	123
	Nabam	<u>Aspergillus niger</u>	
	Ferbam	<u>Neurospora sitophila</u>	283
	Selenium	<u>Aspergillus niger</u>	289
	Captan	<u>Saccharomyces pastorianus</u>	166
	Arsphenamide, Neoarsphenamide, Silver arsphenamide, Arsenoxide, Bismuth,	<u>Spirocheta pallida</u>	53

	HgCl ₂ Filipin	<u>Saccharomyces cerevisiae</u> , <u>Aspergillus flavus</u> , <u>Zygorhynchus moelleri</u>	79
	Ethylene thiuram disulphide	<u>Alternaria brassicicola</u>	50
	Difolatan	<u>Saccharomyces pastorianus</u>	164
	Oxine	<u>Aspergillus niger</u> <u>Botryosphaeria ribis</u>	308, 309
Homocysteine	Phenylmercuric nitrate	<u>Escherichia coli</u> , <u>Staphylococcus aureus</u> , <u>Eberthella typhosa</u>	262
	Selenium Captan	<u>Aspergillus niger</u> <u>Saccharomyces pastorianus</u>	289 166
Glycylcysteine, N-acetylcysteine	HgCl ₂ , Allyl-2-propene-1- thiosulfinate	<u>Salmonella paratyphi</u>	14
Histidine	Phenyl pantothenone Cobalt Oxine	<u>Saccharomyces cerevisiae</u> <u>Proteus vulgaris</u> <u>Aspergillus niger</u> , <u>Botryosphaeria ribis</u>	297 228 308
	Oxine Penicillin G Thiram	<u>A. niger</u> <u>Escherichia coli</u> <u>Aspergillus niger</u>	309 66 122
	Sodium dimethyldithio- carbamate	<u>Saccharomyces cerevisiae</u>	73
8 Imidazole deri- vatives	Sodium dimethyldithio- carbamate	4 Fungi	124
Glutathione	Phenylmercuric nitrate	<u>Escherichia coli</u> , <u>Staphylococcus aureus</u> , <u>Eberthella typhosa</u>	262
	Ferbam Selenium Captan Arsphenamide, Neoarsphenamide, Silver arsphenamide, Arsenoxide, Bismuth, HgCl ₂ Filipin	<u>Neurospora sitophila</u> <u>Aspergillus niger</u> <u>Saccharomyces pastorianus</u> <u>Spirocheta pallida</u>	283 289 166 53
	Difolatan	<u>Saccharomyces cerevisiae</u> <u>Zygorhynchus moelleri</u> , <u>Aspergillus flavus</u> <u>Saccharomyces pastorianus</u>	79 164
D-Alanyl-D-alanine	Cycloserine	<u>Bacillus subtilis</u>	67

Hadacidin	6-Azaauracil	<u>Escherichia coli</u>	239
Urethan	Sulfanilamide	Luminous bacteria	117
	Sulfanilamide	<u>Vibrio phosphorescen</u> ,	118
	Sulfanilamide	<u>Photobacterium phosphoreum</u>	180
		<u>Streptococcus hemolyticus</u> ,	
		<u>Escherichia coli</u>	
Dithizone	Oxine	<u>Stemphylium sarcinaeforme</u>	308
Thiosulfate	Clavacin, Penicillic acid	5 Bacteria	71
Peptone	Atabrine	<u>Escherichia coli</u>	245
	Penicillin,	<u>E. coli</u>	65
	Streptomycin,		
	Aureomycin,		
	Chloromycetin,		
	Terramycin,		
	Bacillin		
	Sulfonamide	<u>E. coli</u>	139, 167
	Sulfathiazoles	<u>Salmonella enteritidis</u>	190
	Sulfanilamide	<u>Streptococci</u>	161
	Al(NO ₃) ₃ ,	<u>Monilia sitophila</u>	145
	Fe(NO ₃) ₃		
	CaCl ₂ ,	<u>M. sitophila</u>	146
	FeCl ₃ ,		
	CuCl ₂ ,		
	ZnCl ₂ ,		
	CoCl ₂ ,		
	CdCl ₂ ,		
	HgCl ₂		
	Diamidines	<u>Staphylococcus aureus</u> ,	21
		<u>Balantidium coli</u>	
	Ascochitine	<u>Cochliobolus Miyabeanus</u>	197
	Sulfathiazole	<u>Staphylococcus aureus</u>	237
		<u>Escherichia coli</u>	
Tryptone	Sulfonamide	<u>E. coli</u>	167
Polyamines	Atabrine	<u>E. coli</u>	245
Spermine, Spermidine	Atabrine	<u>E. coli</u>	184, 245
	Propamidine, Quinine	<u>E. coli</u>	184
Protein	Cephalothin, Cephaloridine, Cefazolin	<u>Sarcina lutea</u>	281
Gelatin	CuSO ₄	<u>Alternaria solani</u>	137
Lipoprotein	Boromycin	<u>Bacillus subtilis</u>	199
	Enniatin (D, S),	<u>B. subtilis</u>	198

	Nanactin, Polymyxin B, Valinomycin, Cetyl-trimethylammo- nium bromide		
Albumin	Penicillins (X, G, K, Dihydro F)	<u>Streptococcus hemolyticus</u>	264
	Sulfonamide	<u>Escherichia coli</u>	42
	Nystatin	<u>Saccharomyces cerevisiae</u>	147
	Copper dimethyldithio- carbamate	<u>Glomerella cingulata</u>	263
	Sulfaethylthiadiazole, Sulfisoxazole, Sulfamethoxypyridazine, Sulfadiazine	<u>Escherichia coli</u>	9
Casein	Sulfonamide	<u>E. coli</u>	167
Enzyme	Cefuzolin	<u>Staphylococcus aureus</u>	64
	Penicillin	<u>S. aureus</u>	1, 153
	Penicillin	<u>Escherichia coli</u>	203
	Chloromycetin	<u>Proteus vulgaris</u> , <u>Bacillus subtilis</u>	246
	Chloromycetin	<u>Escherichia coli</u>	195
	Gentamicins	<u>Staphylococcus aureus</u>	31
	Gentamicin	<u>Escherichia coli</u>	18
	Kanamycin	<u>Bacillus subtilis</u>	304, 305
	Kanamycin	<u>Escherichia coli</u>	18, 195, 196
	Streptomycin	<u>E. coli</u>	196
	Dihydrostreptomycin	<u>E. coli</u>	195
	Neamine	<u>E. coli</u>	18
	Neamine	<u>Bacillus subtilis</u>	305
	Butirosin A, Ribostamycin	<u>B. subtilis</u>	305
	Lividomycin A	<u>B. subtilis</u>	141
	Paromamine	<u>Escherichia coli</u>	196
	Neomycin, Hybrimycin, Nebramycin	<u>E. coli</u>	18
	Colistin	<u>E. coli</u>	110
	Thiram, Copper, dimethyldithio- carbamate	<u>Glomerella cingulata</u>	263
<u>Nucleic Acids and Related Compounds</u>			
Purine	Sulfanilamide	<u>Lactobacillus arabinosus</u>	250
	Sulfonamide	<u>Escherichia coli</u>	139
Adenine	Sulfanilamide, Sulfadiazine, Sulfapyridine, Sulfathiazole	<u>Streptococcus hemolyticus</u>	175

	Benzimidazole	<u>Saccharomyces cerevisiae</u>	298
	Cycloheximide	<u>Fomes annosus</u>	88
	5-Amino-7-hydroxy- triazolo pyrimidine	<u>Ophiostoma multiannulata</u> , <u>Lentinus amphilodes</u>	68
Guanine	Benzimidazole	<u>Saccharomyces cerevisiae</u>	298
	2-Heptadecyl-2-imi- dazoline	<u>Sclerotinia frutcticola</u>	292
	Cycloheximide	<u>Fomes annosus</u>	88
	5-Amino-7-Hydroxy- triazolo pyrimidine	<u>Ophiostoma multiannulata</u>	68
Xanthine	2-Heptadecyl-2-imi- dazoline	<u>Sclerotinia fruticola</u>	292
	Cycloheximide	<u>Fomes annosus</u>	88
	5-Amino-7-hydroxy- triazolo pyrimidine	<u>Ophiostoma multiannulata</u>	68
Hypoxanthine	Aza-adenine	<u>Lactobacillus brevis</u> , <u>L. arabinosus</u>	301
Uracil	Cycloheximide	<u>Fomes annosus</u>	88
	Aureomycin	<u>Escherichia coli</u>	
Adenosine	Nystatin	<u>Candida albicans</u>	72
Guanosine	Amphotericin B	<u>C. albicans</u>	72
	Aureomycin	<u>Escherichia coli</u>	66
Xanthosine	2-Heptadecyl-2- imidazoline	<u>Sclerotinia fruticola</u>	292
Inosine	Aureomycin	11 Bacteria	66
Cytidine	Adenosime	<u>Neurospora sp.</u>	163
Nucleic acid	Aureomycin, Dihydrostreptomycin, Chloromycetin, Terramycin Diamidines	<u>Colpoda cucullus</u>	158
	Stilbamidine	<u>Staphylococcus aureus</u> <u>Balantidium coli</u> <u>Leishmania donovani</u> , <u>Trichomonas vaginalis</u>	21 21
Nicotinamide- ribose nucleo- tide	Sulfapyridine	<u>Lactobacillus arabinosus</u>	261
Lumichrome	Aureomycin	11 Bacteria	66
Coenzyme A	Captan	<u>Saccharomyces pastorianus</u>	166
Coenzyme I	Sulfapyridine	<u>Lactobacillus arabinosus</u>	261

Lipids and Related Compounds

Palmitic acid, Stearic acid	Nystatin	<u>Saccharomyces cerevisiae</u>	253
Oleic acid	Nystatin	<u>S. cerevisiae</u>	253
	Nystatin	<u>Candida albicans</u>	72
	Amphotericin B	<u>C. albicans</u>	72
	Ascosin,	<u>Saccharomyces cerevisiae</u>	97
	Fradicin,		
	Prodigiosin,		
	Fungicidin		
	Cerulenin	<u>S. cerevisiae</u>	193
Linoleic acid	Nystatin	<u>S. cerevisiae</u>	253
	Nystatin	<u>Candida albicans</u>	72
	Amphotericin B	<u>C. albicans</u>	72
	Ascosin	<u>Saccharomyces cerevisiae</u>	97
Linolenic acid	Ascosin	<u>S. cerevisiae</u>	97
Pentadecanoic acid	Cerulenin	<u>S. cerevisiae</u>	193
Aliphatic acids	Penicillin	<u>Micrococcus pyogenes</u> var. <u>aureus</u> , <u>Streptomyces faecalis</u>	15
Tween 80	Ascosin,	<u>Saccharomyces cerevisiae</u>	97
	Fradicin,		
	Prodigiosin,		
	Fungicidin		
	Boromycin	<u>Bacillus subtilis</u>	199
Sterols	Filipin	<u>Hansenula subpelliculosa</u> , <u>Penicillium oxalicum</u>	78
	Fungichromin,	<u>P. oxalicum</u>	78
	Amphotericin B,		
	Trichomycin,		
	Rimocidin,		
	Candicidin (A, B),		
	Ascosin,		
	Nystatin		
Cholesterol	Filipin	31 Fungi	79
	Filipin	<u>Hansenula subpelliculosa</u>	78
	Filipin	<u>Saccharomyces cerevisiae</u>	148
	Fungichromin,	<u>S. cerevisiae</u>	79
	Sodium laurylsulfonate		
	Nystatin	<u>S. cerevisiae</u>	148
	Nystatin,	<u>Candida albicans</u>	72
	Amphotericin B		
	Antimycin	<u>Aspergillus niger</u> , <u>Saccharomyces cerevisiae</u>	148

Sitosterol	Filipin	<u>Penicillium oxalicum</u> ,	78, 79
		<u>Hansenula subpelliculosa</u>	
	Antimycoin	<u>Aspergillus niger</u>	148
	Fungichromin,	<u>Penicillium oxalicum</u>	79
	Amphotericin B,		
	Trichomycin,		
Ergosterol	Rimocidin,		
	Candididin (A, B),		
	Ascosin,		
	Nystatin		
Stigmasterol	Filipin	<u>Hansenula subpelliculosa</u>	78
	Filipin	<u>Neurospora crassa</u>	120
	Antimycoin	<u>Aspergillus niger</u>	148
	Amphotericin B,	<u>Neurospora crassa</u>	120
	Nystatin		
	Cerulenin	<u>Saccharomyces cerevisiae</u>	193
Lichesterol	Filipin	<u>Hansenula subpelliculosa</u>	78
	Antimycoin	<u>Aspergillus niger</u>	148
Lichesterol	Filipin,	<u>Neurospora crassa</u>	120
	Nystatin,		
	Amphotericin B		
Lanosterol, Ergosterone	Filipin	<u>Hansenula subpelliculosa</u>	78
Lecithin, Phytol	Boromycin	<u>Bacillus subtilis</u>	199
Thiotic acid	Propionate	<u>Streptococcus faecalis</u>	99

Vitamins and Related Compounds

Vitamin A. (Retinol)	Nystatin,	<u>Candida albicans</u>	72
	Amphotericin B		
Vitamin B ₁ (Thiamine)	Furacin	<u>Escherichia coli</u>	82
	Aureomycin,	<u>E. coli</u>	66
	Chloromycetin		
	Pyrithiamine	<u>Phycomyces blakesleeanae</u> ,	174
		<u>Ustilago violacea</u>	
Coccarboxylase (Diphosphothiamine)	Pyrithiamine,	<u>Penicillium digitatum</u>	224
	2-Methyl-6-amino- pyrimidine, 2-Methyl-5-ethoxy- methyl-6-amino- pyrimidine		

	Sulfadiazine	<u>Escherichia coli</u>	63
	Sulfadiazine	<u>Mycobacterium tuberculosis</u>	63
	Sulfadiazine	<u>Staphylococcus aureus</u>	151
	Sulfathiazole	<u>Escherichia coli</u>	63, 128
	Sulfathiazole	<u>Staphylococcus aureus</u>	128, 151
	Sulfathiazole	<u>Mycobacterium tuberculosis</u>	63
	Sulfathiazole	<u>Salmonella enteritidis</u>	190
	Sulfathiazole	7 Bacteria	303
	Sulfathiazole	<u>Saccharomyces cerevisiae</u>	149
	Sulfathiazole	<u>Nitzschia palea</u> var. debilis	293
	Sulfaguanidine	<u>Escherichia coli</u>	259
	Sulfaguanidine	<u>Staphylococcus aureus</u>	151
	Sulfaguanidine	<u>Saccharomyces cerevisiae</u>	149
	Sulfonamide	<u>Pseudomonas pyocyanea</u>	270
	Sulfonamide	<u>Acetobacter suboxydans</u>	150
	Sulfonamide	<u>Aspergillus ruber</u>	251
	Sulfonamide	<u>Streptobacterium plantarum</u>	11
	Sulfonamide	<u>Nitzschia palea</u> var. debilis	293
	P-Nitrobenzoate	<u>Streptococcus viridans</u>	183
	Aureomycin	<u>Escherichia coli</u>	66
	Cycloheximide	<u>Fomes annosus</u>	88
Vitamin H (Biotin)	Aureomycin	<u>Escherichia coli</u>	66
	Acidomycin	<u>Mycobacterium tuberculosis</u> var. <u>avium</u>	89
	Desthiobiotin	<u>Sordaria fimicola</u>	155
	Desthiobiotin sulfone	<u>Saccharomyces cerevisiae</u>	52
	Oxybiotin sulfone	<u>S. cerevisiae</u>	103
Desthiobiotin, Heterothiotin	Desthiobiotin sulfone	<u>S. cerevisiae</u>	52
Oxybiotin	Oxybitotin sulfone	<u>S. cerevisiae</u>	103
Vitamin K (Menadione)	2, 3-Dichloro-1, 4- Naphthoquinone	<u>S. cerevisiae</u>	299
Vitamin M (Folic acid)	Aureomycin	<u>Escherichia coli</u>	66
Choline	Phosphoxylcholine, Betaine, Arsenocholine, Triethylcholine, Dimethylethylhydroxy- ethyl-ammonium hydroxide	<u>Neurospora</u> sp.	106

Inositol	Hexachlorocyclohexane	<u>Saccharomyces cerevisiae</u>	130
	Hexachlorocyclohexane	<u>Nematospora gossypii</u>	32
<u>Mineral salts</u>			
Mg ⁺⁺	Vancomycin	<u>Bacillus subtilis</u>	20
	Vancomycin	<u>Pseudomonas fluorescens</u>	51
	Aureomycin	<u>Escherichia coli</u>	223, 226, 227
			252
	Aureomycin	<u>Azotobacter vinelandii</u>	119
	Aureomycin	<u>Pseudomonas aeruginosa</u>	19
	Aureomycin	<u>Shigella flexneri</u>	306
	Terramycin	<u>Pseudomonas aeruginosa</u>	19, 209, 285
	Terramycin	<u>Escherichia coli</u>	252
	Tetracycline	<u>Azotobacter vinelandii</u>	119
	Tetracycline	<u>Pseudomonas aeruginosa</u>	41
	Gentamycin,	<u>P. aeruginosa</u>	41
	Carbenicillin,		
	Polymyxin B		
	Polymyxin	<u>P. aeruginosa</u>	191
	Nocardicin A	<u>P. aeruginosa</u> ,	140
		<u>P. mirabilis</u>	
	Streptomycin	<u>Klebsiella pneumoniae</u>	48
	Novobiocin	Gram negative bacteria	287
	Mitomycin D	<u>Pseudomonas fluorescens</u> ,	51
		<u>Flavobacterium sp.</u>	
	D-Serine	<u>Flavobacterium sp.</u>	51
	Oxine	<u>Micrococcus pyogenes</u>	70
	Oxine	<u>Pythium ultimum</u>	176
	Atabrine	<u>Escherichia coli</u>	244
	Citrate	Lactic acid bacteria	168
Fe ⁺⁺	Aureomycin	<u>Pseudomonas aeruginosa</u>	19
	Aureomycin	<u>Shigella flexneri</u>	306
	Terramycin	<u>Pseudomonas aeruginosa</u>	19, 285
	Terramycin	<u>Micrococcus pyogenes</u>	213
	Kanamycin	<u>Bacillus subtilis</u> ,	278
		<u>Pseudomonas aeruginosa</u> ,	
		<u>Mycobacterium sp.</u>	
	Polymyxin	<u>Pseudomonas aeruginosa</u>	191
	Oxine	<u>Aspergillus niger</u>	8, 171, 276
	Oxine	Gram-negative bacteria	6
	Oxine	<u>Pythium ultimum</u>	176
	Oxine	<u>Micrococcus pyogenes</u>	70
	Copper oxinate	<u>Aspergillus niger</u>	276
	Conalbumin	<u>Bacillus subtilis</u> ,	60
		<u>Micrococcus lysodeckticus</u>	
Fe ⁺⁺⁺	Aureomycin	<u>Shigella flexneri</u>	306
	Copper oxinate	<u>Curvularia lunata</u>	23

Mn ⁺⁺	Aureomycin	<u>Bacillus subtilis</u>	284
	Aureomycin	<u>Escherichia coli</u>	225
	Terramycin	<u>Bacillus subtilis</u>	284
	Terramycin	<u>Pseudomonas aeruginosa</u>	285
	Tetracycline	<u>Bacillus subtilis</u>	284
	Polymyxin	<u>Pseudomonas aeruginosa</u>	191
	Vancomycin	<u>P. fluorescens</u>	51
	Mitomycin D	<u>P. fluorescens</u> ,	51
		<u>Flavobacterium sp.</u>	
	D-Serine	<u>Flavobacterium sp.</u>	51
	Atabrine	<u>Escherichia coli</u>	244
	Oxine	<u>Micrococcus pyogenes</u>	70
	Citrate	<u>Lactic acid bacteria</u>	168
Ca ⁺⁺	Aureomycin	<u>Escherichia coli</u>	223
	Aureomycin,	<u>Micrococcus pyogenes</u> var.	209
	Terramycin	<u>aureus</u>	
	Terramycin	<u>Pseudomonas aeruginosa</u>	209
	Tetracycline,	<u>P. aeruginosa</u>	41
	Gentamicin,		
	Carbenicillin		
	Polymyxin B	<u>P. aeruginosa</u>	41, 209
	Streptomycin	<u>Klebsiella pneumoniae</u>	48
	Dihydrostreptomycin,	<u>Micrococcus pyogenes</u> var.	209
	Neomycin,	<u>aureus</u>	
	Carbomycin,		
	Bacitracin,		
	Oleandomycin		
	Novobiocin	<u>Gram negative bacteria</u>	287
	Nystatin	<u>Saccharomyces cerevisiae</u>	253
	Nocardicin A	<u>Pseudomonas aeruginosa</u> ,	140
		<u>P. mirabilis</u>	
	Atabrine	<u>Micrococcus lysodeikticus</u>	34
Cu ⁺⁺	Atabrine	<u>Escherichia coli</u>	244
	12-Methyltridecanoic acid	<u>Fusarium roseum</u>	152
	Copper	<u>Alternaria alternata</u>	22
	Oxamycin	<u>Pseudomonas fluorescens</u>	288
	Thujaplicin	<u>Saccharomyces cerevisiae</u>	211
	5-Phenyl oxine,	<u>Aspergillus niger</u>	33
	5-Amyl oxine		
	Oxine	<u>A. niger</u>	276
	Copper oxinate	<u>A. niger</u>	23, 276
Co ⁺⁺			
	Oxine	<u>Bacillus subtilis</u> ,	60
		<u>Micrococcus lysodeikticus</u>	
	Oxine	<u>Gram-positive bacteria</u>	6
	Oxine	<u>Aspergillus niger</u>	171
	Oxine	<u>Micrococcus pyogenes</u>	70
	2-picolinic hydrazide	<u>Mycobacterium tuberculosis</u>	59

Zn ⁺⁺	Oxine	Gram negative bacteria	6
	Oxine	<u>Pythium ultimum</u>	176
	Oxine	<u>Ceratocystis ulmi</u> ,	307
		<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	
Ba ⁺⁺	Atabrine	<u>Escherichia coli</u>	244
	Streptomycin	<u>Klebsiella pneumoniae</u>	48
	Novobiocin	Gram negative bacteria	287
Ni ⁺⁺	Copper oxinate	<u>Curvularia lunata</u>	23
Sr ⁺⁺	Novobiocin	Gram negative bacteria	287
Rb ⁺⁺	Nystatin	<u>Saccharomyces cerevisiae</u>	172
K ⁺	Boromycin	<u>Bacillus subtilis</u>	199
	Copper	<u>Alternaria alternata</u>	22
Na ⁺ , H ⁺	Copper	<u>A. alternata</u>	22
SO ₄ ⁻⁻	Selenium	<u>Chlorella vulgaris</u>	241
	Selenium	<u>Aspergillus niger</u>	289
PO ₄ ⁻⁻⁻	Oxamycin,	<u>Bacillus subtilis</u>	288
	Morin,		
	Patulin		
	Usnic acid	<u>B. subtilis</u>	29
MnO ₄ ⁻	Nystatin	<u>Candida stellatoidea</u>	27
	Oxamycin,	<u>Bacillus subtilis</u>	288
	Morin,		
	Patulin		
	Terramycin	<u>Pseudomonas aeruginosa</u>	285
<u>Miscellaneous Compounds</u>			
EDTA	Oxamycin,	<u>Bacillus subtilis</u>	288
	Morin,		
	Patulin		
	Novobiocin	Gram negative bacteria	287
	Oxine	<u>Aspergillus niger</u>	33, 309
	Sodium dimethyldithio- carbamate	<u>Saccharomyces cerevisiae</u>	73
Dithizone	Copper	<u>Alternaria alternata</u>	22
	Oxine	<u>Aspergillus niger</u>	309
		<u>Stemphylium sarcinaeforme</u> ,	
		<u>Monilinia fruticola</u>	
Oxine	Copper oxinate	<u>Curvularia lunata</u>	23

Hemin	Isoniazid, Salicylidene, Benzylidene hydrazone, p-Aminosalicylic acid hydrazide, Picolinic acid hydra- zide, Glycine hydrazide	<u>Mycobacterium tuberculosis</u> var. <u>hominis</u>	62
<u>Mixture and Complex Substances</u>			
Casamino acids (casein hydrolysate)	Chloromycetin, Terramycin Streptomycin, Aureomycin, Bacillin, Penicillin Penicillin G Nocardicin A	<u>Escherichia coli</u> <u>E. coli</u>	65, 66 65
	Quinacrine Sulfathiazole Oxine Oxine Selenium	<u>E. coli</u> <u>Pseudomonas aeruginosa</u> , <u>P. mirabilis</u> <u>Escherichia coli</u> <u>Salmonella enteritidis</u> <u>Botryosphaeria ribis</u> <u>Aspergillus niger</u> <u>A. niger</u>	66 140 214 190 308 308, 309 289
Yeast extract (Basamine)	Aureomycin	<u>Pythium ultimum</u> <u>P. rostratum</u> , <u>P. irregulare</u>	274
	Aureomycin Streptomycin Streptomycin	<u>Escherichia coli</u> <u>E. coli</u> <u>Pythium ultimum</u> <u>P. rostratum</u>	65, 66 65 274
	Dihydrostreptomycin Chloromycetin, Terramycin Bacillin, Penicillin Penicillin G Griseofulvin, Actidione Ascochitine Ascospin Nocardicin A	<u>Escherichia coli</u> <u>E. coli</u> <u>E. coli</u> <u>E. coli</u> <u>Pythium ultimum</u> , <u>P. rostratum</u>	66 65, 66 65 66 274
	Atabrine Sulfanilamide	<u>Cochliobolus miyabeanus</u> <u>Saccharomyces cerevisiae</u> <u>Pseudomonas aeruginosa</u> , <u>P. mirabilis</u> <u>Escherichia coli</u> <u>E. coli</u> , <u>Streptococcus hemolyticus</u>	197 97 140 245 162
	Diamidine	<u>Staphylococcus aureus</u> , <u>Balantidium coli</u>	21
Blood	Sulfanilamide	<u>Streptococcus sp.</u>	69

Serum	Oxacillin,	<u>Staphylococcus</u> sp.	144
	Nafcillin,		
	Ancillin,		
	Methicillin,		
	Cephalothin,		
	Novobiocin,		
	Penicillin (G, V)		
	Penicillin (X, G, K, dihydro F)	<u>Streptococcus hemolyticus</u>	264
	Penicillin (G, V),	<u>Staphylococcus aureus</u>	219
	Phenethicillin,		
	Propicillin,		
	Cloxacillin		
	HQ-Rifamycins	<u>S. aureus</u>	10
	Nystatin	<u>Candida albicans</u>	256
	Phenol,	<u>Staphylococcus aureus</u>	104
	Cetyl-trimethyl-ammonium bromide,		
	Hexylresorcinol,		
	Cetylpyridinium chloride		
	Merthiolate,	<u>Escherichia coli</u>	54
	Castor oil		
	Sulfapyridine	<u>Pneumococcus</u> sp.	25
Plasma	Nystatin	<u>Candida albicans</u>	256
	Sulfaethylthiadiazole,	<u>Escherichia coli</u>	9
	Sulfaisoxazole,		
	Sulfamethoxypyridazine,		
Bile salts	Sulfadiazine		
	Ristocetin,	<u>Staphylococcus aureus</u> ,	230
	Vancomycin	<u>Streptococcus faecalis</u>	
	Polymyxin	6 Bacteria	230
	Amphotericin B,	<u>Candida albicans</u>	229
	Nystatin,		
	Chlorquinaldol,		
Milk	Gentian violet		
	Cetyl-trimethyl-ammonium bromide	<u>Staphylococcus aureus</u>	104
Urine	Sulfanilamide	<u>Streptococcus</u> sp.	69
Vitamin mixture	Penicillin G,	<u>Escherichia coli</u>	66
	Chloromycetin		
Purine + Pyrimidine	Penicillin G,	<u>E. coli</u>	66
	Aureomycin,		
	Chloromycetin,		
	Dihydrostreptomycin		
Animal tissues and extracts	Penicillin,	<u>E. coli</u>	65
	Streptomycin,		
	Aureomycin,		

	Chloromycetin,		
	Terramycin,		
	Bacillin	<u>Saccharomyces cerevisiae</u>	97
	Ascosin	<u>Escherichia coli</u>	139, 167
	Sulfonamide	<u>Lactobacillus arabinosus</u>	261
	Sulfapyridine	<u>Staphylococcus aureus,</u>	21
	Diamidine	<u>Balantidium coli</u>	
Plant tissues and extracts	Mitomycin	<u>Bacillus subtilis</u>	80
	Thiram	<u>Glomerella cingulata</u>	215, 216, 263
	Copper	<u>Alternaria alternata</u>	22, 102
	Copper	<u>Nectria galligena</u>	102
		<u>Gloeosporium perennans</u>	
	Copper	<u>Sclerotinia fructicola</u>	178
	Copper oxychloride	<u>Macrosporium sarcinaeforme</u>	96
	Copper dimethyldithio- carbamate	<u>Glomerella cingulata</u>	263

II. Microbiostasis Increased

N-Acetylgalactosamine, Methionine	Ethylene thiuram disulphide	<u>Alternaria brassicicola</u>	50
Cholesterol	Filipin	<u>Mycoplasma laidlawii</u>	282
Aliphatic acid	Streptomycin	<u>Micrococcus pyogenese</u> var. <u>aureus</u> , <u>Streptococcus faecalis</u>	15
EDTA	5-Phenyl oxine, 5-Amyl oxine	<u>Aspergillus niger</u>	33
Sodium caseinate	Selenium	<u>A. niger</u>	289
Serum	Iodine	<u>Staphylococcus aureus</u>	104
Bile salts	Penicillin, Neomycin	<u>Staphylococcus aureus</u>	230
	Neomycin	<u>Streptococcus faecalis</u>	230
Cu ++	Oxine	<u>Aspergillus niger</u>	8, 33
	Oxine sulphate, Pyridine-N-oxide-2- thiol	<u>A. niger</u>	125
	Sodium dimethyldithio- carbamate	<u>Saccharomyces cerevisiae</u>	74
	Isoniazid	<u>Mycobacterium tuberculosis</u>	206
	Juglone	<u>Bacillus subtilis</u>	258
Co++	Chloromycetin	<u>B. subtilis</u>	267
	Streptomycin, Penicillin, Bacitracin	<u>Micrococcus pyogenes</u>	267
	Aspergillic acid	<u>Mycobacterium tuberculosis</u>	75
	Juglone	<u>Bacillus subtilis</u>	258
	Captan	<u>Saccharomyces pastorianus</u>	165
Zn++	Captan	<u>S. pastorianus</u>	165
	Sodium dimethyldithio- carbamate	<u>S. cerevisiae</u>	74
	Juglone	<u>Bacillus subtilis</u>	258
Mn++, Ni++, Hg++, Al+++	Juglone	<u>B. subtilis</u>	258
Bi+++	Aspergillic acid	<u>Staphylococcus aureus</u>	76
Plant exudates	Zineb	<u>Aspergillus niger</u>	142

TABLE 2. Effects of Nutritional Factors on Soil Fungistasis

Nutritional factor	Material amended with nutrients	Test microorganism	Type of propagule	Reference
I. FUNGISTASIS DECREASED				
<u>Carbohydrates and Related Compounds</u>				
Glucose	Soil	<u>Mucor ramannianus</u>	Sporangiospores	86,87
	Soil	<u>M. silvaticus</u>	Sporangiospores	202
	Soil	<u>Phytophthora cinnamomi</u>	Chlamydospores	185
	Soil	<u>P. parasitica</u>	Mycelia	268
	Soil	<u>Pythium aphanidermatum</u>	Oospores	254
	Soil	<u>P. ultimum</u>	Sporangia	5,255
	Soil	<u>Penicillium frequentans</u>	Conidia	46,47
	Agar disc	<u>P. citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Fusarium solani</u>	Chlamydospores	84
	Soil	<u>F. solani</u>	Conidia	87
	Soil	<u>F. solani f. sp. phaseoli</u>	Chlamydospores	40,233,234
	Soil	<u>F. oxysporum</u>	Chlamydospores	265
	Soil	<u>F. oxysporum</u>	Conidia	87
	Soil extract	<u>F. oxysporum f. sp. cubense</u>	Conidia	257
	Agar disc	<u>Trichoderma koningii</u>	Conidia	235
	Agar disc	<u>T. viride</u>	Conidia	55
	Agar disc	<u>Thielaviopsis basicola</u>	Endoconidia	28
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
	Soil	<u>Glomerella cingulata</u>	Conidia	138
	Soil	<u>Neurospora tetrasperma</u>	Conidia	132
	Soil	<u>Helminthosporium victoriae</u>	Conidia	132
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Soil	<u>Ustilago hordei</u>	Chlamydospores	291
Fructose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Agar disc	<u>Trichoderma koningii</u>	Conidia	235
Galactose	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13

Arabinose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Agar disc	<u>Trichoderma koningii</u>	Conidia	235
Xylose	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Agar disc	<u>T. koningii</u>	Conidia	235
Mannose	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
Sorbitose	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Agar disc	<u>T. koningii</u>	Conidia	235
Ribose	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Sucrose	Soil	<u>Pythium irregulare</u>	Sporangia	274
	Soil	<u>P. ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydo­spores	40, 233, 234
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Soil	<u>Ustilago hordei</u>	Chlamydo­spores	291
Maltose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydo­spores	233, 234
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Agar disc	<u>T. koningii</u>	Conidia	235
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Lactose	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Agar disc	<u>Trichoderma koningii</u>	Conidia	235
Cellobiose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
Raffinose	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Rhamnose	Soil	<u>Aspergillus fumigatus</u>	Conidia	290

Sorbitol	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Dulcin	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Mannitol	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
Succinic acid	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
Citric acid	Soil	<u>Penicillium frequentans</u>	Conidia	47
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Malonic acid, Tartaric acid, Oxalic acid, Ethanol	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Acetaldehyde, Methanol, Isovaleraldehyde	Soil	<u>Sclerotium rolfsii</u>	Sclerotia	156
Shikimic acid, Quinic acid, Malic acid	Soil	<u>Fusarium oxysporum</u> f. sp. <u>lilii</u>	Chlamydo­spores	90
Vanillic acid, Coumalic acid, Cinnamic acid, Ferulic acid, Phlorizin, p-Oxybenzoic acid, Quercetin, Quercitrin	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Chestnut tannin	Soil	<u>Thielaviopsis basicola</u>	Chlamydo­spores	200
	Soil	<u>T. basicola</u>	Endoconidia	200

Proteins and Related Compounds

Asparagine	Soil	<u>Phytophthora cinnamomi</u>	Chlamydo­spores	185
	Soil	<u>P. parasitica</u>	Mycelia	268
	Soil	<u>Pythium aphanidermatum</u>	Oospores	254
	Soil	<u>P. irregulare</u>	Sporangia	274
	Soil	<u>P. ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydo­spores	40, 233, 234

	Soil	<u>F. oxysporum</u>	Chlamydospores	265
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Aspartic acid	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	233, 234
	Agar disc	<u>F. oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Glutamine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	40, 234
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Glutamic acid	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	233, 234
	Soil extract	<u>F. oxysporum</u> f. sp. <u>cubense</u>	Conidia	257
	Agar disc	<u>F. oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Alanine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	234
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Arginine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	234
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Glycine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	40, 234
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Phenylalanine	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	40, 234
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13

Proline	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	234
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Serine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Leucine, Valine, Lysine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Histidine	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Threonine	Soil	<u>Pythium ultimum</u>	Sporangia	5
Cysteine	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
γ-Aminobutyric acid	Soil	<u>Pythium ultimum</u>	Sporangia	5
Peptone	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
Soy bean protein	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
<u>Lipids and Related Compounds</u>				
Linoleic acid,	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
Palmitoleic acid, Trilinolenin, Trilinolenin, Lecithin	Soil	<u>T. basicola</u>	Endoconidia	200
<u>Vitamins</u>				
Vitamin C	Soil	<u>Cochliobolus sativus</u>	Conidia	36, 37, 38
Vitamin E	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
<u>Mineral Salts</u>				
(NH ₄) ₂ SO ₄	Soil	<u>Phytophthora cinnamomi</u>	Chlamydospores	185
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115

NH ₄ Cl	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
KOH	Soil	<u>Neurospora tetrasperma</u>	Ascospores	134
	Soil extract	<u>N. tetrasperma</u>	Ascospores	135
Ca(OH) ₂	Soil	<u>Neurospora tetrasperma</u>	Ascospores	134
<u>Mixtures and Complex Substances</u>				
Molasses	Soil	<u>Cochliobolus sativus</u>	Conidia	36, 37, 38
Yeast	Soil	<u>Pythium irregulare</u>	Sporangia	274
Extract	Soil	<u>P. ultimum</u>	Sporangia	5
	Soil	<u>Thielaviopsis basicola</u>	Chlamydo­spores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
	Soil extract	<u>Fusarium oxysporum</u> f. sp. <u>cubense</u>	Conidia	257
	Agar disc	<u>Trichoderma koningii</u>	Conidia	235
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
Malt extract	Agar disc	<u>Trichoderma koningii</u>	Conidia	235
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
Aureomycin + Streptomycin	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydo­spores	2
Penicillin + Streptomycin	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydo­spores	40
Vancomycin + Nystatin	Soil	<u>Phytophthora cinnamomi</u>	Chlamydo­spores	185
Glucose + Vitamin C	Soil	<u>Aspergillus fumigatus</u>	Conidia	132
	Soil	<u>Penicillium frequentans</u>	Conidia	132
Glucose + Peptone	Soil	<u>Neurospora tetrasperma</u>	Conidia	134
Glucose + Asparagine	Soil	<u>Fusarium oxysporum</u>	Chlamydo­spores	247
	Soil	<u>F. oxysporum</u> f. sp. <u>batatas</u>	Chlamydo­spores	247
	Soil	<u>F. oxysporum</u> f. sp. <u>cubense</u>	Chlamydo­spores	247
	Soil	<u>F. oxysporum</u> f. sp. <u>lycopersici</u>	Chlamydo­spores	247
Sucrose + Yeast	Soil extract	<u>Zygorhynchus moelleri</u>	Mycelia	272
extract	Soil extract	<u>Pythium irregulare</u>	Mycelia	272
	Soil extract	<u>P. rostratum</u>	Mycelia	272
	Soil extract	<u>P. sylvaticum</u>	Mycelia	272
	Soil extract	<u>P. ultimum</u>	Mycelia	271
	Soil extract	<u>Trichoderma hamatum</u>	Mycelia	272
	Soil extract	<u>Fusarium oxysporum</u>	Mycelia	272
	Soil extract	<u>Penicillium janthinellum</u>	Mycelia	272
	Soil extract	<u>Gyrodon meruloides</u>	Mycelia	272

	Soil extract	<u>Cortinarius</u> sp.	Mycelia	272
	Soil extract	<u>Thanatephorus praticola</u>	Mycelia	272, 273
	Soil extract	<u>Cenococcum graniforme</u>	Mycelia	272
Sucrose + (NH ₄) ₂ SO ₄	Soil	<u>Fusarium solani</u> f. sp. <u>pisi</u>	Chlamydospores	39
Glucose + NH ₄ Cl	Soil emanation	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Macroconidia	85
Glucose + Alanine + Glutamic acid + Glycine + Proline	Soil emanation	<u>Aspergillus flavus</u>	Conidia	85
Palmitic acid +	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	201
Stearic acid +	Soil	<u>T. basicola</u>	Endoconidia	201
Oleic acid + Linoleic acid + Palmitoleic acid				
(NH ₄) ₂ SO ₄ + CaH ₄ (PO ₄) ₂ + K ₂ SO ₄ + Na ₂ SO ₄ + MgSO ₄	Soil	<u>Penicillium citrinum</u>	Conidia	114
Plant organic matter	Soil	<u>Mucor silvaticus</u>	Sporangiospores	202
	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium culmorum</u>	Conidia	35
	Soil	<u>F. roseum</u>	Conidia	202
	Soil	<u>F. solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	154, 232
	Soil	<u>Aspergillus</u> sp.	Conidia	35
	Soil	<u>A. fumigatus</u>	Conidia	138
	Soil	<u>Arthrobotrys conoides</u>	Spores	58
	Soil	<u>A. arthrobotryoides</u>	Conidia	170
	Soil	<u>Cochliobolus sativus</u>	Conidia	24, 35, 36
	Soil	<u>Cladosporium</u> sp.	Conidia	35
	Soil	<u>C. cladosporioides</u>	Conidia	202
	Soil	<u>Trichoderma</u> sp.	Conidia	35
	Soil	<u>T. viride</u>	Conidia	202
	Soil	<u>Penicillium notatum</u>	Conidia	35
	Soil	<u>P. roqueforti</u>	Conidia	202
	Soil	<u>Monotospora daleae</u>	Conidia	202
	Soil	<u>Stachybotrys atra</u>	Conidia	35
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	231
	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	3, 200, 248, 269
	Soil	<u>T. basicola</u>	Endoconidia	3, 200
	Soil	<u>Ustilago hordei</u>	Spores	35
	Soil	<u>U. hordei</u>	Chlamydospores	291

Plant extracts	Soil	<u>Mucor ramanianus</u>	Mycelia	109
	Soil	<u>Phytophthora parasitica</u>	Chlamydospores	268
	Soil	<u>Fusarium roseum</u> f. sp.	Mycelia	109
		<u>cerealis</u>		
	Soil	<u>F. oxysporum</u>	Chlamydospores	265
	Soil extract	<u>F. oxysporum</u> f. sp.	Conidia	257
	Soil	<u>cubense</u>		
	Soil	<u>F. oxysporum</u> f. sp.	Chlamydospores	265
		<u>vasinfectum</u>		
	Soil	<u>F. solani</u>	Chlamydospores	265
	Soil	<u>F. solani</u> f. sp.	Chlamydospores	265, 266
		<u>phaseoli</u>		
	Soil	<u>F. solani</u> f. sp. <u>pisi</u>	Mycelia	109
	Soil	<u>Cochliobolus sativus</u>	Conidia	24, 36
	Soil	<u>C. sativus</u>	Mycelia	109
	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200, 249,
				269
	Soil	<u>T. basicola</u>	Endoconidia	200
	Soil	<u>T. basicola</u>	Mycelia	109
	Soil	<u>Sclerotium rolfsii</u>	Sclerotia	156
	Soil	<u>Alternaria alternata</u>	Mycelia	109
	Soil	<u>Aspergillus fumigatus</u>	Mycelia	109
	Soil	<u>A. terreus</u>	Mycelia	109
	Soil	<u>A. ustus</u>	Mycelia	109
	Soil	<u>Botrytis cinerea</u>	Mycelia	109
	Soil	<u>Curvularia lunata</u>	Mycelia	109
	Soil	<u>Glomerella cingulata</u>	Mycelia	109
	Soil	<u>Helminthosporium</u>	Mycelia	109
		<u>victoriae</u>		
	Soil	<u>Myrothecium verrucaria</u>	Mycelia	109
	Soil	<u>Neurospora tetrasperma</u>	Mycelia	109
	Soil	<u>Penicillium frequentans</u>	Mycelia	109
	Soil	<u>P. variabile</u>	Mycelia	109
	Soil	<u>Stemphylium sarcinae-</u> <u>forme</u>	Mycelia	109
	Soil	<u>Trichoderma viride</u>	Mycelia	109
	Soil	<u>Verticillium albo-atrum</u>	Mycelia	109
Plant exudates	Soil	<u>Pythium aphanidermatum</u>	Oospores	254
	Soil	<u>P. aphanidermatum</u>	Sporangia	254
	Soil	<u>P. ultimum</u>	Sporangia	255
	Soil	<u>Cochliobolus sativus</u>	Conidia	38
	Soil	<u>Fusarium solani</u>	Conidia	113
	Soil	<u>F. solani</u>	Chlamydospores	113
	Soil	<u>F. solani</u> f. sp.	Chlamydospores	232, 233
		<u>phaseoli</u>		
	Soil	<u>F. solani</u> s. sp. <u>pisi</u>	Chlamydospores	39
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	231
	Soil	<u>Gliocladium roseum</u>	Conidia	113
	Soil	<u>Paecilomyces marquandii</u>	Conidia	113
Animal organic matter and sercretion	Soil	<u>Arthrobotrys conoides</u>	Spores	58
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Penicillium citrinum</u>	Conidia	114

II. FUNGISTASIS INCREASED

Carbohydrates and Related Compounds

Glucose, Fructose, Galactose, Mannose, Arabinose, Xylose, Sorbitol, Maltose, Sucrose, Lactose, Raffinose, Inulin, Mannitol, Sorbitol,	Soil	<u>Sphacelotheca reiliana</u>	Spores	143
Cellulose	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydo-spores	4
Chitin ,	Soil	<u>Verticillium dahliae</u>	Conidia	121
Laminarin	Soil	<u>V. dahliae</u>	Microsclerotia	121
	Soil	<u>V. dahliae</u>	Mycelia	121

Proteins and Related Compounds

Asparagine	Soil	<u>Phytophthora parasitica</u>	Chlamydo-spores	268
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Mineral salts

CaO	Soil	<u>Zygorhynchus vuilleminii</u>	Spores	105
	Soil	<u>Penicillium chrysogenum</u>	Conidia	105
	Soil	<u>Trichiderma viride</u>	Conidia	105
CaCO ₃	Soil	<u>Sphacelotheca reiliana</u>	Spores	143
NH ₄ NO ₃	Soil	<u>Phytophthora parasitica</u>	Chlamydo-spores	268
	Soil	<u>Sclerotium rolfsii</u>	Sclerotia	12

Mixtures and Complex Substances

Amino acids	Soil	<u>Sphacelotheca reiliana</u>	Spores	143
Plant organic matter	Soil	<u>Verticillium albo-atrum</u>	Conidia	207
	Soil	<u>V. dahliae</u>	Conidia	121
	Soil	<u>V. dahliae</u>	Microsclerotia	121
	Soil	<u>V. dahliae</u>	Mycelia	121
	Soil	<u>Arthrobotrys arthrobo-</u> <u>tryoides</u>	Conidia	170
Animal organic matter and secretions	soil	<u>Arthrobotrys arthrobo-</u> <u>tryoides</u>	Conidia	170

III. FUNGISTASIS NOT AFFECTED

Carbohydrates and Related Compounds

Glucose	Soil	<u>Phytophthora parasitica</u>	Chlamydospores	268
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Soil	<u>F. decemcellulare</u>	Conidia	87
	Soil	<u>R. roseum</u>	Conidia	202
	Soil	<u>F. solani</u>	Conidia	87
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Soil	<u>P. frequentans</u>	Conidia	87, 152
	Soil	<u>P. roqueforti</u>	Conidia	202
	Soil	<u>Arthrobortys conoides</u>	Spores	58
	Soil	<u>Aspergillus fumigatus</u>	Conidia	132
	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
	Soil	<u>Trichoderma viride</u>	Conidia	202
	Soil	<u>Cladosporium cladosporioides</u>	Conidia	202
	Soil	<u>Monotospora daleae</u>	Conidia	202
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Fructose	Soil	<u>C. sativus</u>	Conidia	36
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	234
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Arabinose	Soil	<u>Cochliobolus sativus</u>	Conidia	24, 36, 27
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
Xylose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
Mannose	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Sorbitose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
Ribose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
Sucrose	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Glomerella cingulata</u>	Conidia	157
	Soil	<u>Penicillium frequentans</u>	Conidia	157
	Soil	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
Maltose	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235

Lactose	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Agar disc	<u>Pestalotia macrotricha</u>	Conidia	235
Melibiose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Raffinose	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Rhamnose	Soil	<u>Pythium ultimum</u>	Sporangia	5
Sorbitol	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
Cellulose	Soil	<u>Sphacelotheca reiliana</u>	Spores	143
Starch	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Sphacelotheca reiliana</u>	Spores	143
	Soil	<u>Ustilago hordei</u>	Chlamydospores	291
Glycogen, Inulin, Arbutin	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Dextrin	Soil	<u>Pythium ultimum</u>	Sporangia	5
Agar	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Citric acid	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Fusarium oxysporum</u> f. sp. <u>lilii</u>	Chlamydospores	90
Malonic acid, Fumaric acid	Soil	<u>Pythium ultimum</u>	Sporangia	5
Lactic acid, Tartaric acid, Sodium acetate, Sodium pyruvate	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Galacturonic acid, Glyceraldehyde	Soil	<u>Verticillium albo-atrum</u>	Microsclerotia	56
Isobutyraldehyde	Soil	<u>Scerotium rolfsii</u>	Sclerotia	156

Methanol	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Naphthalene, acetic acid, Indolebutyric acid, Indoleacetic acid	Soil	<u>Cochliobolus sativus</u>	Conidia	36

Proteins and Related Compounds

Asparagine	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Penicillium frequentans</u>	Conidia	46, 47
	Agar disc	<u>P. citrinum</u>	Conidia	115
	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
Aspartic acid	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Glutamic acid	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Alanine	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Arginine	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Glycine	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Phenylalanine	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Proline	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Serine	Soil	<u>Fusarium solani f. sp. phaseoli</u>	Chlamydospores	234
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Leucine	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Soil	<u>Fusarium solani f. sp. phaseoli</u>	Chlamydospores	234
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Agar disc	<u>Trichoderma viride</u>	Conidia	55

Isoleucine	Soil	<u>Fusarium solani f. sp. phaseoli</u>	Chlamydospores	234
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Valine	Soil	<u>Fusarium solani f. sp. phaseoli</u>	Chlamydospores	234
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Lysine	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Fusarium solani f. sp. phaseoli</u>	Chlamydospores	234
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Histidine	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157
	Soil	<u>F. solani f. sp. phaseoli</u>	Chlamydospores	234
Cystine	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Cysteine	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157
Tyrosine	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157
	Soil	<u>F. solani f. sp. phaseoli</u>	Chlamydospores	234
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
Threonine	Soil	<u>Fusarium oxysporum f. sp. lycopersici</u>	Chlamydospores	234
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Tryptophane	Soil	<u>Fusarium oxysporum f. sp. lycopersici</u>	Chlamydospores	234
	Soil	<u>Aspergillus fumigatus</u>	Conidia	290
	Agar disc	<u>Trichoderma viride</u>	Conidia	55
Methionine	Agar disc	<u>Trichoderma viride</u>	Conidia	55
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum f. sp. lycopersici</u>	Conidia	157

Aminobutyric acid, Aminoadipic acid, Pipicollic acid	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	234
Urea	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
Peptone	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
Zein	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
Casein, Albumin	Soil	<u>Cochliobolus sativus</u>	Conidia	36

Lipids and Related Compounds

Synthetic lecithin	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
Oils	Soil	<u>Cochliobolus sativus</u>	Conidia	36

Vitamins and Related Compounds

Vitamin Bx	Agar disc	<u>Glomerella cingulata</u>	Conidia	157
	Agar disc	<u>Penicillium frequentans</u>	Conidia	157
	Agar disc	<u>Fusarium oxysporum</u> f. sp. <u>lycopersici</u>	Conidia	157
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Vitamin B ₁ , Vitamin B ₅ , Vitamin B ₆ , Vitamin B ₁₂ , Vitamin E, Vitamin G, Vitamin H, Niacin	Soil	<u>Cochliobolus sativus</u>	Conidia	36

Mineral Salts

CaO	Soil	<u>Gonatobotrys simplex</u>	Conidia	105
CaCO ₃	Soil	<u>Fusarium culmorum</u>	Spores	127
Ca(OH) ₂	Soil	<u>Arthrobotrys conoides</u>	Spores	58
	Soil	<u>Neurospora tetrasperma</u>	Conidia	134

HCl	Soil	<u>Cochliobolus sativus</u>	Conidia	38
H ₃ PO ₄	Soil	<u>Fusarium oxysporum</u> f. sp. <u>lilii</u>	Chlamydospores	90
KOH	Soil	<u>Neurospora tetrasperma</u>	Conidia	134
NaNO ₂	Soil	<u>Pythium ultimum</u>	Sporangia	5
NaNO ₃	Soil	<u>Mucor silvaticus</u>	Sporangiospores	202
	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Fusarium roseum</u>	Conidia	202
	Soil	<u>Penicillium roqueforti</u>	Conidia	202
	Soil	<u>Trichoderma viride</u>	Conidia	202
	Soil	<u>Cladosporium cladosporioides</u>	Conidia	202
	Soil	<u>Monotospora daleae</u>	Conidia	202
NH ₄ NO ₃	Soil	<u>Pythium ultimum</u>	Sporangia	5
	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
KNO ₃ , (NH ₄) ₂ SO ₄	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
	Soil	<u>Fusarium solani</u> f. sp. <u>phaseoli</u>	Chlamydospores	40
KNO ₂ , K ₂ SO ₄ , MgSO ₄ , K ₂ HPO ₄ , (NH ₄) ₂ HPO ₄	Soil	<u>Macrophomina phaseolina</u>	Sclerotia	13
<u>Mixtures and Complex Substances</u>				
Casamino acids	Agar disc	<u>Penicillium citrinum</u>	Conidia	115
	Soil	<u>Thielaviopsis basicola</u>	Chlamydospores	200
	Soil	<u>T. basicola</u>	Endoconidia	200
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Sucrose +	Soil extract	<u>Alternaria alternata</u>	Mycelia	273
Yeast extract	Soil extract	<u>Gliocladium fimbriatum</u>	Mycelia	273
	Soil extract	<u>Agaricus silvicola</u>	Mycelia	273
Glucose + Peptone	Soil	<u>Mucor ramanianus</u>	Sporangiospores	136
	Soil emanation	<u>M. ramanianus</u>	Sporangiospores	136
	Soil	<u>Aspergillus fumigatus</u>	Conidia	136
	Soil emanation	<u>A. fumigatus</u>	Conidia	136
	Soil	<u>Penicillium frequentans</u>	Conidia	136
	Soil emanation	<u>P. frequentans</u>	Conidia	136
	Soil	<u>Trichoderma viride</u>	Conidia	136
	Soil emanation	<u>T. viride</u>	Conidia	136

Mineral salts	Soil	<u>Penicillium frequentans</u>	Conidia	47
	Soil	<u>Sphacelotheca reiliana</u>	Spores	143
Plant organic matter	Soil	<u>Ustilago nuda</u>	Spores	35
	Soil	<u>U. hordei</u>	Chlamydospores	291
	Soil	<u>F. solani f. sp. phaseoli</u>	Chlamydospores	4
	Soil	<u>Arthrobotrys conoides</u>	Spores	58
	Soil	<u>Cochliobolus sativus</u>	Conidia	36
Animal organic matter and secretions	Soil	<u>Cochliobolus sativus</u>	Conidia	36
	Soil	<u>Arthrobotrys conoides</u>	Spores	58
	Soil	<u>Fusarium culmorum</u>	Spores	127

TABLE 3. Effects of Nutritional Factors on Soil Actinostasis

Nutritional factor	Material	Test	Reference
	Amended with nutrients	Microorganisms	
I. ACTINOSTASIS DECREASED			
Glucose	Agar disc	<u>Nocardia</u> spp.	30
	Soil	<u>Streptomyces</u> spp.	177
Peptone	Soil	<u>Streptomyces</u> spp.	159
Peptone + yeast extract	Agar disc	<u>Nocardia</u> spp.	44
Casamino acids, Chitin	Soil	<u>Streptomyces</u> sp.	294
Plant exudates	Agar disc	<u>Nocardia</u> spp.	30
Plant organic matter	Soil	An actinomycete	35
	Soil	<u>Streptomyces</u> sp.	294
II. ACTINOSTASIS DECREASED			
Glucose	Soil	<u>Streptomyces</u> sp.	294
Plant organic matter, Animal secretions	Soil	<u>Streptomyces</u> <u>cellulosae</u>	127
III. ACTINOSTASIS NOT AFFECTED			
Fructose Sucrose, Casamino acids, Yeast extract	Agar disc	<u>Nocardia</u> spp.	30
Starch	Soil	<u>Streptomyces</u> sp.	294
CaCO ₃	Soil	<u>Streptomyces</u> <u>cellulosae</u>	127

TABLE 4. Effects of Nutritional Factors on Soil Bacteriostasis

Nutritional factor	Material Amended with Nutrients	Test Microorganisms	Reference
I. BACTERIOSTASIS DECREASED			
Glucose	Agar disc	<u>Achromobacter</u> spp.	30
	Agar disc	<u>Alcaligenes</u> spp.	30
	Agar disc	<u>Pseudomonas</u> spp.	30
	Agar disc	<u>Flavobacterium</u> spp.	30
	Agar disc	<u>Brevibacterium</u> spp.	30
	Agar disc	<u>Arthrobacter</u> spp.	30
	Soil	<u>Escherichia coli</u>	131
	Soil	<u>Bdellovibrio bacteriovorus</u>	131
Mannitol	Soil	<u>Azotobacter chroococcum</u>	126
Peptone	Soil extract	<u>Bacillus prodigiosus</u>	108
Casein	Soil	<u>Bacillus thuringiensis</u>	221
Glucose + peptone	Soil	<u>Agrobacterium radiobacter</u>	13
Peptone + yeast extract	Agar disc	<u>Achromobacter</u> spp.	44
	Agar disc	<u>Arthrobacter</u> spp	44
	Agar disc	<u>Bacillus</u> sp.	43, 44
	Agar disc	<u>Pseudomonas</u> spp	44
	Agar disc	<u>Sarcina</u> sp.	44
Plant exudates	Agar disc	<u>Achromobacter</u> spp.	30
	Agar disc	<u>Alcaligenes</u> spp.	30
	Agar disc	<u>Pseudomonas</u> spp.	30
	Agar disc	<u>Flavobacterium</u> spp.	30
	Agar disc	<u>Brevibacterium</u> spp.	30
	Agar disc	<u>Arthrobacter</u> spp.	30
Plant organic matter	Soil	<u>Pseudomonas fluorescens</u>	127
	Soil	<u>Azotobacter chroococcum</u>	126
	Soil	<u>Bacillus thuringiensis</u>	221
Animal organic matter and secretion	Soil	<u>Pseudomonas fluorescens</u>	127
	Soil	<u>Azotobacter chroococcum</u>	126
CaCO ₃	Soil	<u>Bacillus prodigiosus</u>	108
	Soil	<u>Azotobacter chroococcum</u>	126

MgCO ₃ + Na ₂ MoO ₄	Soil	<u>Azotobacter chroococcum</u>	126
Mineral salts	Agar disc	<u>Achromobacter</u> spp.	30
	Agar disc	<u>Alcaligenes</u> spp.	30
	Agar disc	<u>Pseudomonas</u> spp.	30
	Agar disc	<u>Flavobacterium</u> spp.	30
	Agar disc	<u>Brevibacterium</u> spp.	30
	Agar disc	<u>Arthrobacter</u> spp.	30

II. BACTERIOSTASIS NOT AFFECTED

Fructose, Sucrose, Casamino acids, Yeast extract	Agar disc	<u>Achromobacter</u> spp.	30
	Agar disc	<u>Alcaligenes</u> spp.	30
	Agar disc	<u>Pseudomonas</u> spp.	30
	Agar disc	<u>Flavobacterium</u> spp.	30
	Agar disc	<u>Brevibacterium</u> spp.	30
	Agar disc	<u>Arthrobacter</u> spp.	30
Animal organic matter	Soil	<u>Azotobacter chroococcum</u>	126
CaCO ₃	Soil	<u>Pseudomonas fluorescens</u>	127
NH ₄ NO ₃	Soil	<u>Escherichia coli</u>	131
NaMoO ₄ , K ₂ HPO ₄ , CaH ₄ (PO ₄) ₂ , MgCO ₃	Soil	<u>Azotobacter chroococcum</u>	126

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